A Comparison of Web-Based Concept Mapping Tasks for Alternative Assessment in Distance Teacher Education

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Abstract

Three sections of the same distance education class completed a series of Web-based concept map assessments using one of two methods. Open-ended maps applied in section 1 led students to conduct more relational thinking overall, but variance in map items was very high introducing more subjectivity in scoring. Pre-selected term mapping applied in sections 2–3 led students to correctly classify many concepts and express proper relationships compared to an instructor's map. Identifying expected concept sets from the instructor's maps caused students some difficulty. The high volume of readings associated with the task appeared to further this problem. Students touted many benefits of mapping, including synthesizing and connecting course material, reading more intentionally, and thinking critically.

Introduction

The difficulty in delivering and securing traditional tests at a distance is well known (Shyles, 2002). Concept mapping provides distance instructors with an alternative assessment tool to determine what students know about a relatively narrow domain of knowledge tied to required readings or labs. To complete a concept map, the student is either given or extracts key concepts in a domain, groups terms in "like" sets, and draws lines between terms to illustrate key relationships. The concept map also includes linking words on connecting lines to explain relationships (e.g., clear cutting—*causes*—erosion). Combining concepts and linking words creates a "proposition" that may be evaluated for accuracy (Cardellini, 2004).

Web-based concept map assessments were integrated in three sections of the same graduate teacher education class between fall semesters 2005 and 2006. The sections were taught entirely at a distance using the WebCT Vista (Blackboard, 2007) course management system. Concept maps provided an alternative assessment to gauge student understanding of course topics. The study helped to determine the most appropriate mapping techniques for eliciting and scoring student representations using performance and attitudinal measures.

Concept Map Task Structures and Thinking

Thinking skills may be divided into basic skills and complex processes. Presseisen (2001, p. 49) reflects on numerous taxonomies and suggests five basic skills in increasing complexity: qualifying or identifying basic units and facts, classifying, finding relationships, transforming the known to a unique metaphor or analogy, and drawing conclusions such as causes and effects. These underlying skills are applied to complex thinking processes such as problem solving, decision making, critical and creative thinking.

A number of concept mapping task structures are available that may elicit these thinking skills and processes differentially. Highly structured maps known as "construct-on-scaffold" or "fill-in-the-structure" only require students to define and identify existing knowledge as they fill-in the blanks on a provided hierarchical structure (Chang, Sung, & Chen, 2001; Naveh-Benjamin, McKeachie, Lin, & Neely, 1998).

More challenging are pre-selected term maps that require the student to take a set of given terms, recognize sequences, and deduce relationships from the context of course materials. These maps may provide students with some structure to start their mapping such as superordinate headers, or superordinate concepts may be embedded among the pre-selected terms, requiring the student to generate the appropriate hierarchical structure.

More challenging still are seeded maps where the student must supplement provided terms with a specified number of additional terms selected on their own. This task increases the challenge by requiring students to evaluate information to select important and relevant terms, and to induce relationships based on incomplete information. Like pre-selected term maps, seeded maps may or may not start off with a partial structure to help students integrate new concepts.

Open-ended maps are perhaps the most challenging, providing no terms for the student, only a topic for mapping. Open-ended maps provide more opportunities for students to explain and externalize their understanding (Ruiz-Primo, Shavelson, Li, & Schultz, 2001), and students are more likely to generate original knowledge representations through this format. However, the higher-level thinking skills required in open-ended mapping (evaluating information, inferring appropriate information to represent a domain, inducing relationships) present a challenge for even advanced learners.

In one study, 26 college students were unable to represent arguments in their maps that would support integrative statements about theories of learning (e.g., "all learning is under the control of reinforcers") (DeSimone, Schmid, & McEwen, 2001, p. 270). Even given some structure for their map in the form of integrative statements, students did not spontaneously apply higher-level inferencing skill and compile evidence in maps to build arguments for the statements. In another study with 17 undergraduates using concept maps and shared journals to reflect on the nature of science, students did not revise their initial propositions over the course of a semester (Germann & Young, 2001).

Active teacher scaffolding may be required to reach higher levels of thinking with maps, rather than assuming students will spontaneously apply reasoning (DeSimone et al., 2001). DeSimone et al.'s (2001, p. 280) students requested ongoing feedback regarding "their apparent understanding of the content." Researchers have developed scaffolds that might help students gauge the correctness of their understanding in a concept map environment. The MindNet tool includes a concept library and map analyzer, allowing learners to review the propositions and cluster the maps of other teams, promoting reflection on divergent perspectives and discussion among a team regarding their own structure

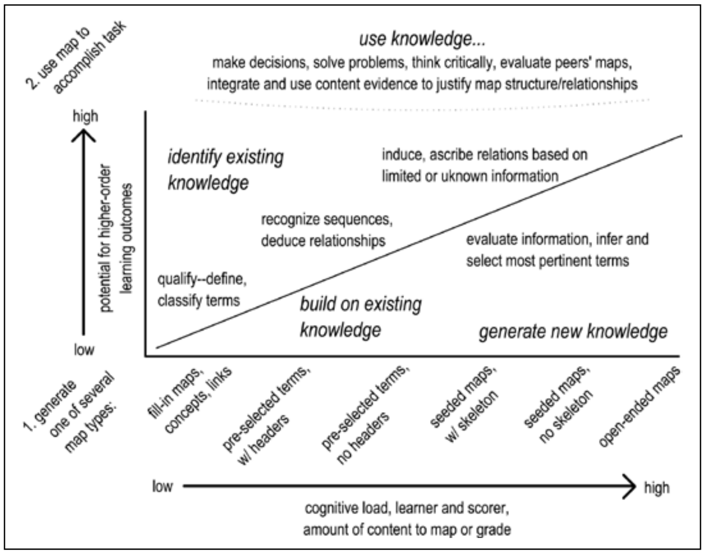

Figure 1: Thinking skills and processes supported by different mapping tasks.

(Cheung, 2006). Also, similarity indices allow learners to evaluate how well their map compares to peer and expert structures. The Cmap tool includes "knowledge soups" for individuals or teams to share propositions with others who can evaluate and re-use posted propositions (Institute for Human and Machine Cognition, 2007).

After students create any of the map types discussed in this section (fill-in-the-blank, pre-selected, seeded, open-ended), they can use this knowledge to engage in complex thinking processes such as decision making and problem solving (Tergan, Graber, & Neumann, 2006). For example, a teacher might ask students to reflect on the relationships between air pollution and asthma in their concept map, and then make decisions for appropriate controls. Scaffolding may also be required for students to appropriately use the knowledge in their maps for complex thinking processes.

Figure 1 represents the theoretical model created by the researcher for this study. In the framework, the thinking skills and processes suggested by Presseisen (2001) and Tergan et al. (2006), are grounded in the context of different concept map task structures. Fill-in and pre-selected term maps are suggested to require lower-level thinking skills and less cognitive challenge, while seeded and open-ended maps are suggested to require both lower- and higher-level thinking skills and more cognitive challenge. Teachers can task students with 1) constructing concept maps and exercising related thinking skills, and/or 2) using the knowledge in a completed concept map to engage in complex thinking processes (problem solving, decision making, etc.).

Using Concept Maps for Assessment

A variety of methods are available for scoring concept maps, including a comparison of the student-created map to an expert or criterion map, a computed score based on map elements, or a combination of both (Ruiz-Primo & Shavelson, 1996). McClure, Sonak, and Suen (1999) outline at least two additional scoring systems: structural, or computing a score from higher-level structures, cross-links, and propositions; and relational, or computing a score from propositions alone. The relational method is touted for its ease of use, mechanical simplicity, and increased reliability, allowing scores to be easily defended.

Others suggest, however, there is too much data in concept maps to focus on relationship statements alone (Cañas et al., 2004). The volume of data held in concept maps is increasing through new computer tools that enhance the static *concept* map to a more descriptive *content* map with attached external resources (e.g., notes, Web links, digital library resources, images) (IHMC, 2007; Tufts University Academic Technology, 2005). Across map types from pre-selected to open-ended, students can use content to elaborate on a structure they have generated or to justify their structure on the basis of attached external evidence.

Scoring maps on the basis of multiple characteristics takes time and increases cognitive load for the scorer, particularly for the new *content* map format with multiple external resources. It is understandable why some would limit the scope of mapping assessments to fill-in-the-structure, and to no surprise such maps correlate closely with standard multiple choice tests (Schau, Mattern, Zeilik, Teague, & Weber, 2001). They should, since students are not creating an original structure, but repeating core knowledge as on a multiple choice test. In this study, both open-ended and pre-selected term maps were investigated as promising task structures beyond fill-in maps. Reflections on student performance and teacher scoring should assist others interested in applying concept map assessments to distance teacher education courses.

Method

The purpose of this study was to compare two concept mapping methods (pre-selected term maps, open-ended maps) and judge their merit as alternative assessments for distance teacher education. Research questions include:

1. How successful are teachers on different mapping tasks in terms of accurately representing assigned reading material in visual form?
2. What thinking skills are supported by different mapping tasks?
3. What are teacher reactions to different mapping tasks?
4. Is one mapping task more appropriate for student assessment or for student thinking/learning?

Participants

Study participants included 41 graduate students enrolled in three sections of the same graduate distance education course taught by the researcher over three semesters. The graduate course was based on topics associated with the integration of technology and related issues in K-12 schools. The distance course was delivered asynchronously on the *WebCT Vista* course management system (Blackboard, 2007). Almost all participants were full-time, in-service teachers matriculating part-time at the university toward a Master's degree, with only a few non-teaching students in the sample. Section 1 included 11 students (8 female, 3 male). Sections 2–3 included 30 students (27 female, 3 male). The grade levels and subject areas taught by teacher participants varied widely, however many taught high school business education courses. Most of the enrollees had limited prior knowledge of concept mapping. Students in sections 2–3 were asked on a course pre-survey if they had ever created an electronic concept map before, and 76.9% indicated "no" they had not.

Materials

Cmap Tools freeware enabled students to develop online concept maps and attach external resources to their maps (IHMC, 2007). Each student downloaded and installed the program on his or her computer. Cmap is practical for distance courses, since it allows instructors to store student folders and map templates on servers for remote access, and students separated by distance can co-edit shared maps. IHMC's public Cmap servers were utilized for beta testing with section 1, and the researcher installed a Cmap server on campus for use with sections 2–3.

Students used Cmap to represent concepts from course resources and readings. In section 1, students were required to integrate external resources with their maps, but they were not told which resources to integrate (e.g., course readings, Web links). In sections 2–3, students

were also required to integrate external resources with their maps, but the resources were limited to electronic copies of assigned readings placed in each student's map folder.

Also placed in each student's map folder were one or more map templates. For section 1, blank map files were added to the students' folders to which the students added their own concepts and began their open-ended mapping. For sections 2–3, pre-selected term maps based on instructor maps were added to student folders. To create each instructor map, key terms were selected from assigned reading material and organized around a set of superordinate headers (e.g., see Figure 2). To create the corresponding pre-selected term map for students, the links and structure were simply removed from the instructor map (see Figure 3).

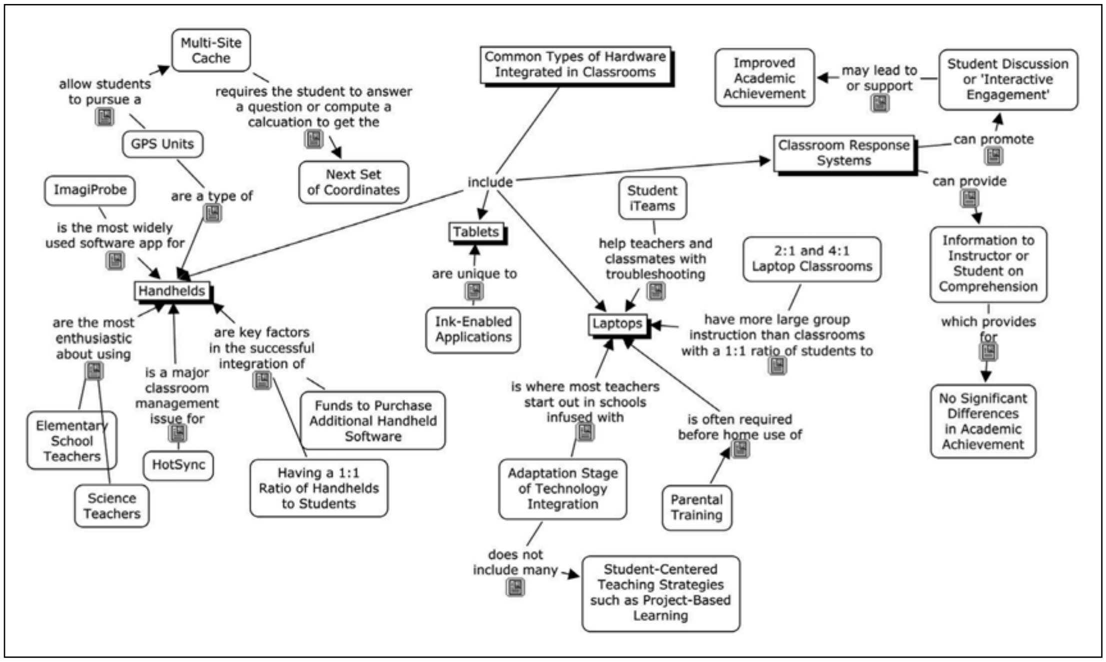

Figure 2. Instructor map illustrating concept classifications, sets, and propositions.

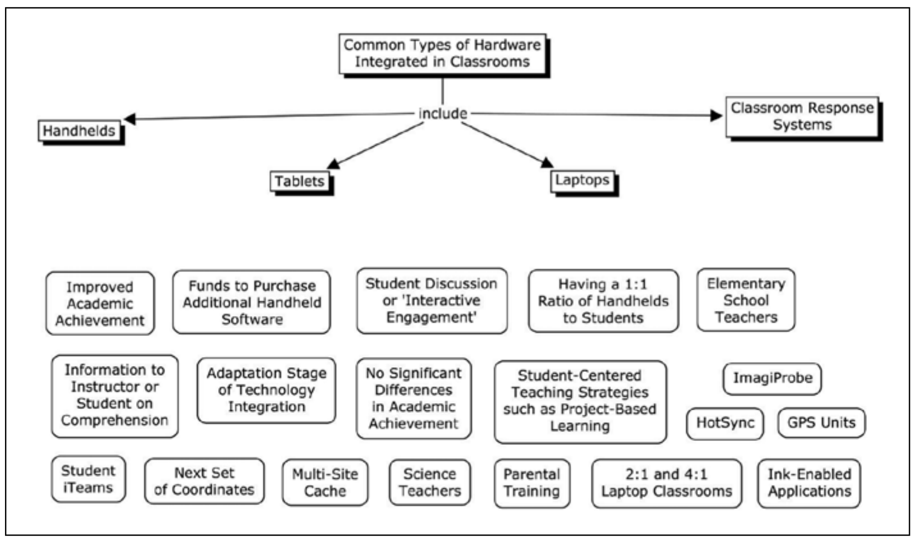

Figure 3: Student pre-selected term map created from instructor map.

Procedures

Students completed between two and three concept maps related to course resources and assigned readings. In section 1, open-ended maps were employed with no terms provided to students in advance. Students were responsible for extracting relevant concepts from the course resources and readings, organizing and relating them, and integrating external resources to illustrate where they found depicted relationships.

In sections 2–3, students were provided with approximately 20 pre-selected terms in advance of their reading, and they were responsible for organizing and relating those terms on their maps. Three or four superordinate concepts were listed at the top of each map under which students classified their terms. Table 1 summarizes assigned map activities by section.

Table 1: Summary of Courses, Students, and Mapping Activities.

Section	*Enrolled*	*Maps Completed and Content Coverage*	*Task Structure*
Section 1, Fall 05	11 students	2 individual maps: the Internet (2 weeks, 8 articles) influencing factors on tech integration (1 week, 4 articles)	open-ended, no terms provided
Sections 2–3, Summer 06, Fall 06	15 students each	3 individual maps: hardware (3 weeks, 7 articles) software (4 weeks, 14 articles) the Internet (3 weeks, 14 articles)	pre-selected terms provided

Analysis

A case study design was employed with section 1 and sections 2–3 representing two separate units of analysis. Across sections, three student data sources were used: a log of student questions posed to the instructor regarding assigned mapping tasks, student responses to an online survey, and concept map artifacts. The online survey queried students as to such items as the usefulness of the Cmap assignment, how much course content should be used in creating a Cmap, whether students preferred to work on Cmaps alone or collaboratively, and how well Cmap helped students make conceptual connections within and between course sessions.

The conceptual analysis method of content analysis was applied to questions received by the students as well as open-ended survey comments, identifying frequently used keywords and sorting text by themes. Numerical student survey responses were summarized with descriptive statistics, and a multivariate analysis of variance (MANOVA) was employed to determine any differences in response between cases.

Methods for scoring concept maps varied by section. For section 1, the number of concepts, correct propositions, and integrated resources were tallied. Further, content analysis was applied to individual maps to identify the superordinate or higher-level categories students placed

in their maps (i.e., major themes). Categories are often exemplified with several specific underlying concepts, and thus easy to identify on a map. Figure 4 illustrates an excerpt from one student's map about influencing factors on technology integration. While this student's full map included 41 concepts, if it were scored as shown it would be credited with 17 relevant concepts, 19 correct propositions, and 6 embedded resources as illustrated by the square icons just below several of the concept boxes (e.g., below "administrator roles"). Further, this sample map includes five superordinate categories, each with several underlying concepts, starting clockwise with professional development, collaboration, budgeting, hardware and connectivity, and staffing.

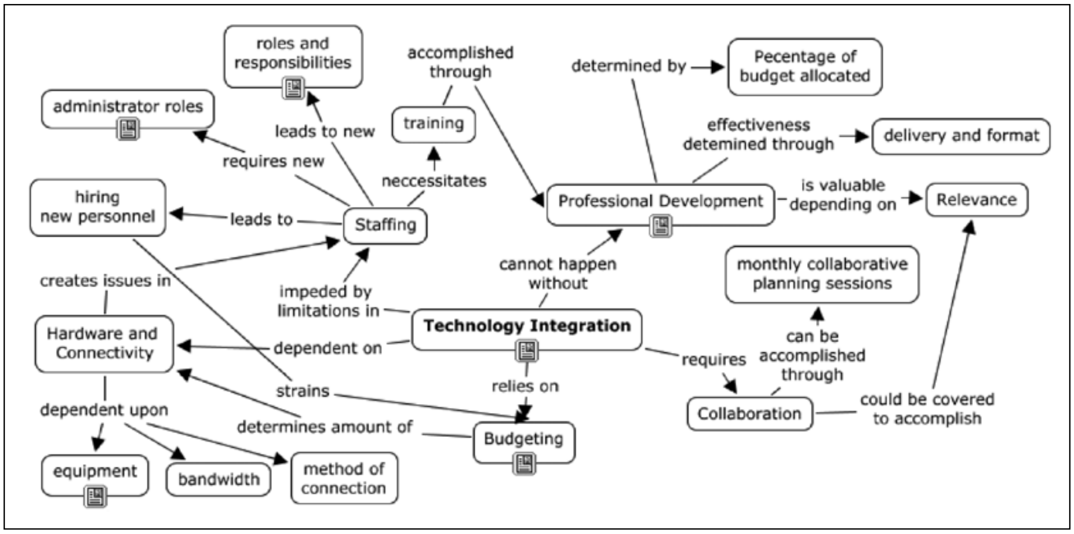

Figure 4. Excerpt from student open-ended map.

In an effort to create a scoring scenario that was less subjective, pre-selected term maps were employed for sections 2–3. A combination scoring method was employed, assigning one point for each concept, concept set, and proposition on the students' maps that were similar to items on a comparison instructor's map (Ruiz-Primo & Shavelson, 1996).

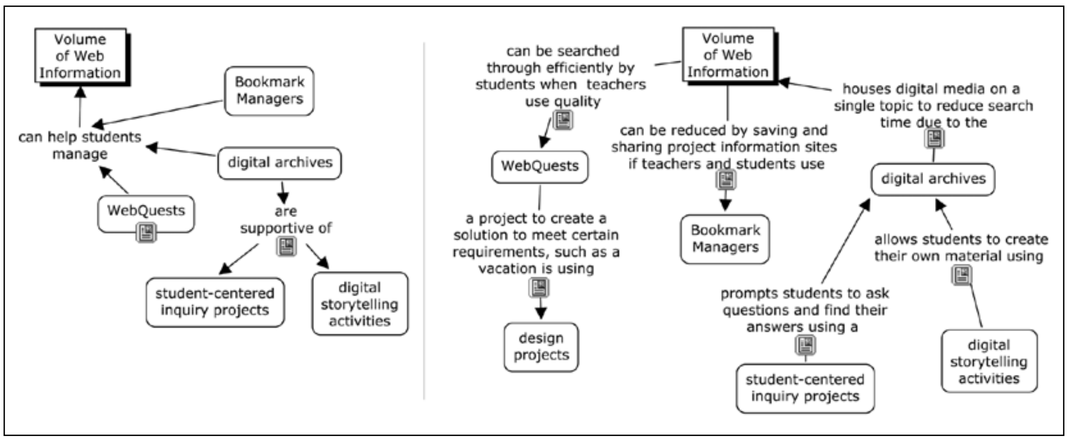

Figure 5. Comparison of excerpts from instructor map (left) and student pre-selected term map (right).

An excerpt from one instructor map is shown in Figure 5 from which students could receive five points for correctly classifying shown terms in any way under the header, and another two points for grouping terms in sets—WebQuests, digital archives, and bookmark managers with volume of Web information, and digital archives with student-centered inquiry projects and digital storytelling activities. Where three or more concepts were co-located in a set, the student had to place all concepts together to receive one point. A half-point was assigned if only some of the concepts were placed together.

On the student map shown in Figure 5, the student received five points for classifying all of the expected terms under the header (one extra term, design projects, was incorrectly classified), and one point for identifying the concept set associated with digital archives. The student also received six points for correct propositions. Even though the concept "design projects" was incorrectly classified by comparison to the instructor's map, the student's proposition relating this concept to "WebQuests" was accurate.

Results

Open-Ended Mapping

In section 1, students placed an average of 34.7 and 37.3 concepts respectively in their two open-ended concept maps of the type illustrated in Figure 4 with a highly divergent standard deviation of 21.8 and 23.4 respectively (see Table 2). The number of correctly written propositions and unique resources integrated in student maps also had a high overall variance. High variance on open-ended map tasks has been reported by others (Shaka & Bitner, 1996).

Table 2: Section 1 Concept Map Results.

concept map	*# of maps scored*	*# of concepts identified*		*# of resources attached*		*# of proposition statements*	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
internet (2 weeks)	11	34.7	21.8	20.5	11.6	28.4	13.4
factors (1 week)	10	37.3	23.4	16.6	11.3	34.1	18.8

Using content analysis, the major categories represented on students' open-ended maps were noted (i.e., the higher-level terms on which they placed the most importance). Table 3 presents the superordinate categories cited most frequently on open-ended student maps and some of the underlying concepts suggested by students.

The categories on open-ended student maps clearly represented topics introduced in course units; thus each student was successful at representing at least some of the major unit topics on their maps. However, since most student maps contained only three or four categories among seven or eight possible, the data further illustrate considerable divergence in the focus of student maps. Students emphasized different topics on their maps they found most important or relevant.

For assessment, it was helpful to analyze all student maps as shown in Tables 2–3 before assigning points, to develop a standard indicator of performance. The decision to deduct points was admittedly subjective, based on a holistic consideration of concepts, unit themes represented, propositions, and resources.

Table 3: Categories and Underlying Concepts Cited Most Frequently on Internet (n=11) and Influencing Factors Maps (n=10).

Map	*Major Categories on Student Maps*	*# of Maps Citing*	*Underlying Concepts Shared by Students*
internet	communication tools	11	blogs, bulletin boards, listservs, e-mail, podcasts, chat, messaging, conferencing
	copyright	8	acceptable use policies, internet resources, fair use, public domain
	collaboration tools	7	wikis, blogs, class Web pages, global learning projects—thinkquest
	networks	7	LAN, WAN, servers, wireless, modems, DSL, cable, shared tools
	Internet resources for teachers	7	digital archives, Webquests, government sites, online publications, professional organizations, lesson plan sharing
factors	funding, budgeting	9	budget, business and industry, government, NSF, grants, seed money, collection development plans, leasing, fundraising, competing needs, restrictive conditions
	professional development	8	on learning theories, on research-based best practice models that are replicable, on teaching/mentoring/coaching skills, for teachers and administrators, collaborative teams, e-learning, in-service
	planning	6	school technology/improvement plans, district/state/national technology plans, shared decision making, goals, strategies, evaluation, SWOT analysis, STAR Charts, collaborative planning
	standards	5	ISTE, 21st Century Skills, No Child Left Behind Act, state technology model, national technology plan
	administrative or leadership support	5	hiring risk takers, flexibility with time, provides resources and professional development, mentors, models, advocates, change agents

One procedural advantage noted for open-ended mapping was the ability for students to customize their maps to address personal interests. For the Internet map in particular, a few cases were noted where a student who taught a subject such as writing would integrate writing-related concepts and external resources.

Pre-Selected Term Mapping

Pre-selected term maps of the type illustrated in Figure 3 and scored in Figure 5 objectively depicted student understanding of specific topics. As shown in Table 4, students correctly classified more than 80% of pre-selected terms under the superordinate headers provided for each of the three assigned maps. Students also generated between 9 and 14 correct propositions for each map. No correct number of propositions was assumed, but Table 4 indicates the number of propositions on each instructor map for general comparison.

Students experienced the most difficulty identifying specific concept sets. Compared to the instructor's map, students only identified 39.4% of the expected concept sets on their first map, and improved slightly to 51.2% and 57.9% for their second and third maps respectively. The difficulty students had identifying the same concept sets as the instructor might be attributed to the depth of each topic, with between 7 and 14 articles assigned for each of three maps. Four students in sections 2–3 commented on their post-survey that maps were based on too much content:

> Too many articles to try to find the connections. Smaller Cmaps would have been more useful for me.
>
> There may have been too many articles to relate.

With so many articles, students would sometimes find alternative groupings for concepts that were different from the instructor's map but still valid. Five students in sections 2–3 commented on their post-survey that alternate conceptions were possible:

> Sometimes an idea was vague to me to tie it to a particular reading, or I felt it could be tied more than one way.
>
> I think that sometimes people could make different connections.

Providing pre-selected terms to locate and organize across a selection of readings did encourage better reading among students in sections 2–3. When asked what was most beneficial about Cmap on their post-survey, seven students indicated Cmap helped them to read more thoroughly and to go back and re-read:

> It also forced me to go back and carefully examine all the readings—even though I had read them previously, I always found something I had sort of skimmed over or didn't remember.
>
> It also gave me a reason to go back to the readings and really internalize the information.
>
> Required me to REALLY read over the material. A person might fake their way through some of the discussion, but the Cmap was proof positive that I had thoroughly read the material.
>
> It made me think about the readings on a deeper level.
>
> By having to dissect the readings in order to do the CMaps, I really digested the information.

Table 4: Concept Map Scores for Sections 2–3 Completing Pre-selected Term Maps.

Map	*# of Maps Scored*	*# of Super. Concepts*	*Concepts Classified*		*Sets Identified*		*Propositions*	
			Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Hardware	30	4	16.6/19 (84.7%)	3.1	2.4/6 (39.4%)	1.8	13.6/17 (80%)	5.6
Software	28	4	16.3/20 (81.4%)	2.6	4.6/9 (51.2%)	2.0	12.7/17 (74.8%)	3.7
Internet	28	3	13.8/16 (85.9%)	1.8	5.2/9 (57.9%)	1.3	9.7/12 (80.7%)	4.2

The results presented in Table 4 illustrate that students were able to structure and relate specific concepts from their readings in a manner moderately similar to the instructor's map. The class averages were useful to assign points, with students falling below the averages receiving fewer points. The standard deviations for concepts classified, sets identified, and propositions were lower overall than the standard deviations for similar points of analysis in open-ended maps, reducing subjectivity in scoring. Proposition writing was the skill that varied most across students who completed pre-selected term maps.

Student Reactions to Mapping

Regardless of mapping method, student reactions to Cmap as an alternative assessment were positive. When asked to choose between a traditional exam and a Cmap assessment on their post-survey, more than 90% of students in each section chose Cmap (see Table 5). When given more choices, including applied projects and a combination of assessment methods, a majority of students in each section still chose Cmap as the preferred mode.

Students were also asked on their post-survey if they agreed or disagreed Cmap was a useful course assignment. Using a 5-point Likert scale, 86.2% of students from section 1 and 87.2% of students from sections 2–3 agreed or strongly agreed that Cmap was useful. Among three students who verbalized a dislike for Cmap in written survey comments, they still believed the tool was educational:

> Personally I hate doing them, but they are effective tools for learning. Therefore, the least beneficial aspect is my personal dislike; however there is no educational downside.
>
> Not so much useful, but it was a new experience. It challenged beyond memorization.

Many students in sections 2–3 indicated that just learning to use Cmap itself was beneficial. Some teachers in the course indicated they had adopted or would adopt concept mapping as a strategy with their own students:

> The Cmap activity was immensely useful because it armed us with at least one strategy that we could immediately use in our classrooms.
>
> Since I had never done one, it was beneficial to experience it as a possible tool to use in my own classroom.
>
> I loved them! We will be doing these in my class in 2006–07!
>
> During this course, I have incorporated concept mapping into my classes. My students now use Inspiration.

Discussion

Thinking with Cmaps

The study framework presented in Figure 1 suggests students who construct pre-selected term maps and open-ended maps may engage in different thinking skills. Study data suggest this is true.

When asked what was most beneficial about Cmap on their post-survey, students who completed open-ended maps in section 1 were more likely to suggest the tool helped them think critically about the course readings, perhaps because their task required additional higher-level skills tied to evaluating and selecting pertinent information for the map:

> Using Cmap helps to develop critical thinking skills, not just memorization skills.
>
> I think Cmap helps students with critical thinking.
>
> [It] provoked thought.
>
> It did help clarify my thinking, and I feel helped me better retain the information that I read.

When asked the same question, 41% of students who created pre-selected term maps suggested the tool helped them make connections, tie information together, link information, or group information. The ability to explicate relationships was the thinking skill that students constructing pre-selected term maps attributed to Cmap most often. This finding is also consistent with the study framework which suggests pre-selected term maps support recognizing sequences and deducing relationships:

Table 5: Percentage of Students Preferring Different Methods of Assessment In Distance Teacher Education Courses

		Section 1 n=11	*Sections 2-3 n=30*
If you could choose between a Cmap assessment or a regular exam, which would you select?	Cmap	90%	93.1%
	Regular Exam	10%	6.9%
If you could choose between Cmaps, regular exams, or applied projects, which form of assessment would you select?	Cmap	40%	48.3%
	Regular Exam	0%	3.4%
	Applied Projects	30%	13.8%
	Combination	30%	34.5%

> Making connections among concepts was most beneficial.
>
> It forced me to understand and make connections between essential course concepts.
>
> Cmapping helps to tie information together.
>
> It allowed me to connect all the articles and ideas together for each session.

When asked if Cmap helped them to make connections within specific course sessions and between course sessions, 100% of students in section 1 and more than 75% of students across sections 2–3 agreed or strongly agreed on a 5-point Likert scale (see Table 6). A slightly smaller percentage of students in sections 2–3 agreed that Cmap helped them to make connections *between* sessions of the course. The opposite effect was predicted, since students in sections 2–3 prepared maps from 3–4 weeks of course material compared to students in section 1 who prepared maps from only 1–2 weeks of course material. It may be that the restrictive nature of pre-selected term mapping, however, left students in sections 2–3 with the impression of connecting fewer concepts overall even though their maps were based on more material. In fact, they did relate fewer concepts overall (see mean number of written propositions from Tables 2 and 4). One student in section two commented that pre-selected term maps may lead students to read for specific information and miss other general ideas in the process:

> I think since we were given topics ahead of time, it affected how I read the articles. I was reading for specific information, which can be timely and helpful, but I missed some important facts, I discovered upon re-reading.

Pre-selected term maps do not necessarily keep students from gaining "big picture" understanding as suggested by several students in sections 2–3:

> It allowed me to see the "big picture" and make connections with all the concepts.
>
> It helped me to see the big picture.

The "big picture" in pre-selected term maps, however, must be deduced from the instructor's terms rather than induced from the student's own evaluation of material at large, which the study framework suggests in contrasting deduction in pre-selected term maps with induction in open-ended maps. As several students suggested, pre-selected term maps were more about deducing the instructor's model of content than constructing their own:

Table 6: Percentage of Students Who Agree or Strongly Agree With Different Values of Concept Mapping Activities

The Cmap activity helped me to make connections...	*Section 1 n=11*	*Sections 2-3 n=30*
within a specific session of the course.	100%	82.8%
between sessions of the course.	100%	75.9%

Table 7: Percentage of Students Agreeing or Strongly Agreeing that Different Map Strategies Can Be Useful.

Please rate whether you agree/disagree the following cMap strategies were or could be useful:	*Section 1 n=11*	*Sections 2-3 n=30*
strategy one: developing a focused cMap that covers only 1–2 sessions of content	100%	79.3%
strategy two: developing a general cMap that covers several sessions of content (e.g., sessions 3–11)	40%	24.1%
strategy three: building a Cmap week by week over the whole semester	57.2%	69%
strategy four: developing a Cmap for the whole semester, but only at the end of semester	0%	13.8%

> Seeing the terms that the instructor considered important for each session [was beneficial].
>
> The only problem I had was that there is little room for difference of opinion with you. I gathered different ideas and perspectives from some of the articles....
>
> I would like to be able to add other connections that were discussed in the readings.
>
> Map open for interpretation; however, had to match instructor's thoughts.

Effects of Content Depth

On a 5-point Likert scale, students were asked on their post-survey if they agreed or disagreed that different concept map strategies varying by depth of coverage could be useful. Strategy one referred to developing focused Cmaps covering only 1–2 sessions of a course. Although this was deemed the most useful strategy by students in both section 1 and sections 2–3 (see Table 7), a multivariate analysis of variance (MANOVA) revealed a significant main effect for group, $F(1, 33) = 4.4$, $p < .05$, $\eta^2 = .118$. Students in section 1 suggested the strategy would be more useful than students in sections 2–3, perhaps because section 1 had already experienced some success with focused mapping.

Overall, students in both section 1 and sections 2–3 rated semester-long, iterative maps (strategy three) more useful than maps covering several sessions of content (strategy two). This preference may stem from students valuing a long-term, but dynamic and changing map. Or for students in sections 2–3, the preference may stem from struggles with strategy two--mapping content from several sessions of content. All students rejected strategy four—a one-shot, non-iterative map covering an entire semester of content and developed at the end of the semester.

Proclivity for Independent Work

Students in all three sections worked independently on their maps. In the first section, students were told they could collaborate, but only two students chose to work together on their second map. On their post-survey, students were asked on a 5-point Likert scale if they agreed of disagreed that working alone or working collaboratively could be useful strategies for developing concept maps. As shown in Table 8, only 37–40% of students agreed or strongly agreed that co-developing Cmaps with other classmates

Table 8: Percentage of Students Who Agree or Strongly Agree with the Usefulness of Individual and Collaborative Concept Mapping

Please rate whether you agree/disagree the following cMap strategies were or could be useful:	*Section 1 n=11*	*Sections 2-3 n=30*
developing a Cmap by myself	100%	39.3%
co-developing a Cmap with another classmate	40%	37.9%

could be useful. The idea of working collaboratively was not well received by the distance students in this course, perhaps because most worked full-time and would have difficulty scheduling group mapping sessions. Regardless, the benefits of collaborative mapping are well documented and should not be ruled out based on student preferences alone (Danish & Enyedy, 2007; DeSimone et al., 2001).

With regard to mapping alone, a multivariate analysis of variance (MANOVA) revealed a significant main effect for group, $F(1, 33) = 6.6$, $p < .05$, $\eta^2 = .167$. Section 1 had a significantly higher percentage of students who agreed that developing a Cmap alone could be useful. This finding is somewhat unexpected, since one might expect students tasked with open-ended mapping and the multiple thinking skills required of it to desire more support from peers. The application of pre-selected term maps in sections 2–3, however, required students to search through numerous articles to find assigned terms. Perhaps the challenge added by this need to search for and contextualize specific concepts may have led students in sections 2–3 to rate the usefulness of independent mapping lower. Students in section 1 may have struggled less and required less collaborative support, since they could integrate any concept or resource they found important into their open-ended maps.

Conclusions

In this study, two different methods of Web-based concept mapping were investigated as a form of alternative assessment for distance teacher education. Each method was found to have both advantages and disadvantages.

For open-ended mapping, students in section 1 were led to integrate more overall concepts and engage in more relational thinking about those concepts. Students constructing open-ended maps were also more likely to discuss thinking critically about course material consistent with the study framework, which suggests the strategy requires students to evaluate information, induce meaning, and generate a new knowledge structure from a body of information at large. Open-ended maps were found to be more flexible in allowing students to customize and integrate their own topics of interest and external resources. It follows that great variance was evident in the number of concepts and propositions integrated in open-ended maps which may present a problem for graders with more divergent information to score.

With pre-selected term maps, students in sections 2–3 were limited to a specific set of concepts and thus engaged in less relational thinking overall compared to the open-ended mapping group. Pre-selected mapping led students to recognize sequences and make connections among course material, consistent with the study framework. The strategy encouraged students to read in order to locate specified terms, but focus and thinking were more directed toward deducing the fit of these terms within the context of focused sections of text. Even though students suggested their pre-selected term maps helped them acquire "big picture" understanding, this understanding may be better defined as a reconstruction of the instructor's mental model of important course content rather than a student's personal construction of what they found important. This finding has implications for assessment, with pre-selected term maps akin to a matching task on a test using instructor-provided terms, contrasted with an original essay. Customization of pre-selected

term maps is discouraged in order to provide a standardized result that can be scored objectively. This manifests in lower overall variance in the number of concepts, sets, and propositions, which may be appropriate for educators seeking a precise assessment instrument.

For teacher educators, a recommendation is not entirely appropriate for one concept mapping task structure over another. Educators interested in fostering relational thinking about a course topic may opt for open-ended mapping, particularly if the maps are assigned as a project or activity and not a scored assessment. Open-ended mapping can be used for assessment, but teachers should realize the subjective nature of the scoring task and be comfortable with general content analysis. Educators concerned with designing an objective assessment may find that pre-selected term mapping carries more precision. In theory, pre-selected term maps carry less cognitive load, but as evidenced by this study, increased content depth may increase the mental challenge significantly with students required to search through material to locate and contextualize provided terms. Thus, content depth should be carefully considered when assigning pre-selected term maps.

Overall, concept mapping was well received by students across all sections and has become both a valuable learning and assessment tool in this course. Perhaps the greatest indicator of success is the large number of teachers in the course who have adopted concept mapping in their own teaching after their initial exposure to the strategy.

Concept maps are still used in this course. Specifically, open-ended maps are employed with students working in small groups of three to co-construct a body of knowledge and engage in more relational thinking than pre-selected term maps could provide. To manage the resulting subjectivity in scoring open-ended maps, an additional task is assigned to students whereby they use the knowledge in their map to make a decision for adopting some aspect of technology integration (e.g., create a concept map comparing handheld computing, one-to-one computing, and classroom response computing, and make a decision as to which hardware system your school should implement using findings/data from your map to justify your decision). It is the students' decisions and rationale for their decisions that are emphasized in scoring, rather than the details of their maps. The map is used as a means to an end, rather than the end product itself. This usage is consistent with the two-part study framework that suggests students may both build maps using core thinking skills and then use the knowledge in their maps to engage in complex thinking processes like decision making.

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implemented in this project provide promising results for the use of online approaches to teaching science content to preservice teachers.

In "A Comparison of Web-based Concept Mapping Tasks for Alternative Assessment in Distance Teacher Education," Kevin Oliver presents an innovative approach to testing in a distance education environment. Using three different approaches to concept mapping assessment, Oliver presents data on student use of these different concept mapping assessment approaches. His results provide a positive picture for the use of concept mapping assessment in distance education environments.

In the final article in this issue, "A Model for Facilitating Field Experiences in a Technology-Enhanced Model Pedagogical Laboratory," Yuxin Ma, Doug Williams, Louise Prejean, Guolon Lai, and Mary Jane Ford describe a laboratory experience that uses technology to provide a practice teaching environment for preservice teachers. Among other methods, the authors use the Teachers' Beliefs Regarding Technology Use Survey (TBTUS) (Park & Ertmer, 2007), to evaluate the effectiveness of the laboratory experience and obtain provocative results.

It is clear that interest in creating and studying innovation is part of the glue that holds our community together, both in terms of our practice and research and writing. Connecting with the ITEST community will contribute to this shared purpose and strengthen both communities.

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Awbrey, "sustainable change is not something that is imposed on the culture—it emerges from the culture's self-examination" (p. 14).

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